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Mining in Maine: Past, Present, and Future

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INTRODUCTION

Mining in Maine has a long history unknown to many citizens. Some of us have seen the granite quarries which remain from an industry established more than 150 years ago. Gravel pits are a common sight today, and many people are familiar with Maine's limestone, slate, and crushed stone operations. However, the well-known resources of modern times are but a few of the mineral products that have been produced in Maine. Economic conditions, technological developments, and world events have influenced the level of mining activity in our state. The history of mining in Maine is presented here in light of those influences.

The mineral resources in Maine were formed during a chain of geologic events spanning hundreds of millions of years. A complex assortment of volcanic rocks, granite intrusions, and sedimentary rocks have evolved and changed through eons of time. This setting has imposed many uncertainties, both technological and financial, on finding and developing commercial mineral deposits. Because the state receives long-term economic benefits from the minerals industry, the means should be found to encourage exploration and development of our mineral resources in ways that will serve the best interests of the State of Maine.

THE EARLY YEARS: PRE-CIVIL WAR

The first evaluation of Maine's mineral resources was authorized by the State Legislature in the spring of 1836. Recognizing that a geological survey would surely aid Maine's

economy, the Board of Internal Improvements contracted Charles T. Jackson of Boston to conduct the survey. Jackson's field work was limited by funding, weather, and available transportation to coastal areas and major river and overland routes. However, in his third and final report, submitted in 1839, Jackson concluded that Maine had a wealth of mineral resources and could easily become as important an industrial state as the rest of New England. He felt that Maine could become self-sufficient in the production of peat, lime, roofing slate, granite, and certain metals, and should be able to market these products in other states.

By 1836, when Jackson began his survey, mining in Maine was already established on a small scale. The commodity of greatest importance at that time was granite. Maine had several advantages that made it the principal supplier of granite to the rest of the Atlantic states and the West Indies. The greatest advantage was that most of the important quarries were readily accessible by navigable rivers, bays, or inlets. Thus the shipping costs for Maine granite were considerably less than for other types of building stone. High quality granite was abundant and available in such a wide variety of colors and textures that virtually any demand could be met. Quarrying was concentrated around Penobscot Bay, eastern Washington County, Hallowell, Biddeford, and the Blue Hill area.

Maine was also well known for its limestone quarrying in the early 1800's. Activity was concentrated then, as it is now, in the Thomaston area. Jackson estimated that at least \$14 million worth of limestone lay within 20 feet of the surface in Thomas-

ton. The annual lime production was valued at about one-half million dollars. It was used for agriculture and the manufacture of wall plaster (Jackson, 1838).

Fine quality roofing slate, equal to that traditionally imported from Wales, was discovered northwest of Bangor. Prospective quarries were opened in several towns, but Jackson's report suggests that only a small volume of slate was produced in the early 1800's (Jackson, 1838). The only metal mines operating at the time were the Newfield Iron Works, which produced bog iron to be shipped to Boston, and the lead mines near Lubec. Jackson (1838) also mentioned a few other mineral products that had been mined in small quantities, including ornamental serpentine in Deer Isle and diatomite in Newfield.

The sixth and seventh Annual Reports of the Secretary of the Board of Agriculture, published in 1861 and 1862, contain another assessment of mining in Maine and the potential for future exploitation of the state's mineral resources. Although perhaps not as optimistic as Jackson's publications, these reports by State Geologist Charles Hitchcock supported the assumption that Maine was blessed with sizable reserves of certain commodities, particularly granite, limestone, peat, slate, and metals.

During the mid-1800's, Maine still supplied much of the East with granite. The coastal areas were dotted with quarries producing granite for domestic use and export. The manufacture of lime products near Thomaston, Rockland, and Rockport remained Maine's other major mineral industry. Roofing slate was mined in the vicinity of Brownville, and metal mining continued on a small scale. The Newfield Iron Works was still in operation, while a new lead mine was opened near Lubec by the Maine Mining and Manufacturing Company.

A new mining operation was begun at Katahdin Iron Works following the discovery of iron ore by Moses Greenleaf (the first map maker of Maine) in 1848. That same year, the first charcoal furnace was built a mile from the workings. It was enlarged several times in later years to handle increased production. The other new mining venture of the period was the beginning of feldspar mining in Topsham in 1852 (Cameron and others, 1954). Maine feldspar was used for many years thereafter as an ingredient in china and other ceramic materials. As with the granite quarries, the pegmatites in Topsham were profitable to work in the 1800's because of their proximity to the sea.

THE CIVIL WAR TO WORLD WAR II

The most notorious development in Maine's mining history was the metal mining boom of 1879 to 1882. The origin of this boom is unclear, though it is said that men returning from the gold rushes in the West found a similarity between the metal-bearing rocks of Maine and ore deposits of the western states (Perkins, 1941). There was great excitement as mining companies were organized, buildings were erected, expensive machinery was installed, and in some cases mills, concentrators, and smelters were constructed. Much of the activity occurred around Blue Hill, Sullivan, Acton, and Lubec. It soon reached

such a high level that a weekly industry newspaper, the "Maine Mining Journal", was published in Bangor beginning in 1880. Perkins (1941) wrote a very interesting account of this mining boom in Maine.

Promotion and development continued until 1883, when metal prices dropped. The mines in the Blue Hill area were the first to close, and were soon followed by the silver mines around Acton and Sullivan. Other newly opened metal mines quickly followed suit. Katahdin Iron Works continued to produce despite having to rebuild the furnace that was almost completely destroyed by fire in 1882. Mining and smelting at this locality ceased in 1890 due to depletion of the higher-grade ore and competition from producers in the Lake Superior iron district. The hematite/magnetite ore from the latter district was richer in iron and lacked the undesirable sulfur that was present in Katahdin ore.

Although prospecting continued and several metal mines reopened for a short time, no major mining occurred in Maine during the remainder of the 1800's. There was a brief period of activity in Cherryfield around 1905-07, when the price of silver was favorable (J. R. Rand, pers. comm.). The shipment of copper concentrates from the Douglass Mine in Blue Hill by American Smelting and Refining Co. in 1918 marked the last production of base metals from Maine mines until the late 1960's.

Limestone and feldspar continued to be produced through the late 1800's and into the twentieth century. Thomaston and Rockland remained the center of limestone quarrying, though other deposits were worked in Union and Warren. Feldspar mining continued around Topsham, and production began in the pegmatites of Oxford and Androscoggin Counties. The construction of processing mills at Auburn in 1897 and West Paris in 1925 was the key factor in promoting feldspar mining in these counties (Perham, 1987).

The state's feldspar production reached a yearly high of about 12,000 tons by the late 1920's, almost ceased during the depression, but recovered to about 5,000 tons per year in the late 1930's. Perham (1987) has described the growth of the feldspar industry in Maine, along with the important role of the Perham family and other individuals in developing the mines of Oxford County.

Mica was mined sporadically from Maine pegmatites during the late 1800's and early 1900's. It was used for stove windows and electrical insulating material (Cameron and others, 1954). Bastin (1911) provided an excellent review of the mining, economics, and uses of feldspar and mica in Maine during the early 1900's. Gemstones and mineral specimens were significant byproducts of this mining.

The granite industry reached its high point in 1901, with 152 quarries employing at least 3,500 men. Maine ranked first in the country in terms of value of granite produced. Maine granite was used for everything from bridge supports and piers to tombstones. Many public buildings, churches, and monuments, particularly in New York City, are constructed of Maine

granite. Examples include the State House in Augusta, Maine; post offices in Philadelphia, Buffalo, Hartford, and Albany; custom houses in St. Louis, Boston, and Brooklyn; Grant's Tomb in New York; paving stones in New York and Philadelphia; and the gatehouse in Central Park.

The value of granite produced in Maine declined between 1911 and 1922, but recovered by the mid 1920's, with paving blocks accounting for more than half of the total production. However, the development of Portland cement as a building material in the early 1900's, and the depression of the 1930's, dealt Maine's granite industry a blow from which it would never recover. Production in later years was small and sporadic. Dale (1907) and Grindle (1977) have extensively described the state's granite quarries and industry.

Several other mineral commodities were produced in Maine prior to World War II. Beginning in the 1920's, Monson slate was used in making large electrical switchboards such as those in Boston and Philadelphia subway stations. Maine slate was also used for roofing material and the beds of the finest pool tables. Peat deposits were exploited, primarily for local agricultural purposes, and diatomite for polishing compounds was excavated from deposits scattered around the state. Brickyards thrived along the coast, where there was sufficient clay to make bricks for both local use and shipment to other eastern states.

THE WAR YEARS OF THE 1940'S

Two events in the early 1940's stimulated the exploration and development of Maine's mineral resources. One was the establishment of the State Geological Survey under the Maine Development Commission; the other was the outbreak of World War II.

In 1942, the Maine State Legislature enacted a bill placing the State Geological Survey under the jurisdiction of the Maine Development Commission. To carry out its part of the Commission's program, the Survey had a fourfold function:

"1) to give service to landowners and prospectors through the identification and examination of mineral and rock specimens and prospects;

2) the exploration and mapping of areas which appear to have economic prospects for mineral development;

3) laboratory research directed towards the discovery of new or improved techniques that may make possible economic advances in the commercial development of our mineral resources; and

4) the dissemination of information on the geology and mineral resources of Maine, through publication, correspondence, and talks before various groups." (Trefethen, 1949)

When World War II began, the Maine State Geologist, along with geologists throughout the country, became concerned with meeting the increased mineral requirements of the wartime economy. The danger of shipping materials from overseas further stimulated the need to develop domestic mineral sources. This meant searching for new deposits, reexamining old ones,

and developing the technology to utilize previously uneconomic deposits. Of particular concern were minerals on the War Department's "strategic list". The list was based on the country's experience during World War I and included those minerals essential to national defense that came primarily from foreign sources. Trefethen (1943) reviewed the status of strategic and other mineral resources in Maine. His report focused on mica and manganese ore, which were considered to be the most significant strategic minerals occurring in the state.

Both scrap and high-grade mica were essential to electrical industries. As much of the better mica had been imported prior to the war, the Maine Geological Survey searched for local deposits in cooperation with the U.S. Geological Survey, U. S. Bureau of Mines, and the Colonial Mica Corporation (the company given federal authority to purchase domestic mica) (Trefethen, 1943). These groups examined the many mines and prospects located in the mica-bearing pegmatites of western Maine.

Mica production in Maine was significant during the war years. One of the principal companies involved in this work was the Douglass Mining Company, operated by Dana Douglass, Jr. However, despite government assistance and high wartime prices, most mica operations were barely able to break even. Mining for mica in Maine declined when the war ended.

In view of the urgent need for manganese to meet the demands of the steel industry, work began in the summer of 1941 to evaluate manganese deposits in Aroostook County that had been discovered over 100 years before. The project was placed under the State Military Defense Commission. Both the State and U.S. Geological Surveys, and the U. S. Bureau of Mines, conducted mapping and other studies of the deposits. Samples collected in the field were analyzed, and extraction methods were tested at the Massachusetts Institute of Technology.

The Manganese Ore Company, a subsidiary of the M. A. Hanna Company, began prospecting the larger, more promising deposits in 1942. Altogether, the work during the war years indicated reserves of metallic manganese in Aroostook County of about 2,100,000 tons. The average manganese content of the ore is about 9 percent. At that time, however, a process by which manganese could be extracted economically from the type of ore found in Aroostook County had not been developed.

Limestone production was Maine's most important extractive industry during the war years. It was produced mainly by three companies operating in the Rockland area. The chief products were agricultural limestone, burned lime, cement materials, and chemical limestone for use in the paper industry. Investigations showed that Maine had enough dolomite to assure local production of magnesium lime for many years. This would be especially important to Maine's potato industry as much of the soil in Aroostook County is deficient in magnesium.

Peat was harvested in a number of Maine towns during the early 1940's, including Centerville, Deblois, Franklin, Friendship, Jonesport, Penobscot, and Sullivan. The peat was used exclusively for agricultural or horticultural purposes. Fuel

wood shortages and rising costs of other fuels prompted the Maine Development Commission to investigate the use of peat as an energy source. Field work was conducted by the Maine Geological Survey and laboratory analysis by the University of Maine Technology Experiment Station. The results of the survey were published in Bulletin No. 1 of the Maine Geological Survey. The quality of Maine peat is generally very good.

In addition to being investigated as a source of mica, pegmatites were evaluated for their beryl, spodumene, and feldspar content. Beryl, the main ore of beryllium, and spodumene, a lithium ore, were important in the production of metal alloys. Unfortunately, both minerals occur only sporadically in Maine pegmatites, and production was limited to that found as a byproduct of mica or feldspar mining. Feldspar, on the other hand, remained one of the more important mineral commodities in the state. Several large quarries were operated in Oxford and Sagadahoc counties.

Slate continued to be mined and milled in the Monson area for use primarily as insulating panels on electric switchboards. Reported occurrences of asbestos and graphite were investigated by the Maine Geological Survey, but the deposits were never developed commercially. The Survey also conducted studies of Maine clays to determine the type and distribution, as well as the quality, potential uses, and beneficiation of clay deposits.

The Katahdin Iron Works pyrrhotite deposit was studied through a cooperative effort by the Maine Geological Survey and the U.S. Geological Survey as a possible source of sulfur. The results of the study were published in Maine Geological Survey Bulletin 2. The deposit, which had been mined intermittently during the last century, was estimated to have about 5,800,000 tons of iron and 3,300,000 tons of sulfur for every hundred feet of depth.

The war had both good and bad impacts on exploration and development of mineral resources in Maine. On the one hand, exploration for both strategic and non-strategic minerals previously supplied from overseas was stimulated. Much valuable geologic information resulted from this activity. However, the mineral extraction industry as a whole, especially producers of construction materials such as crushed rock, sand and gravel, cement, slate, and structural clay products, were affected adversely. They were impacted not only by poor market conditions, but also by manpower shortages and equipment procurement problems. Despite increased demand for some materials, output actually diminished.

THE POSTWAR YEARS: 1940'S TO 1960

In the late 1940's and early 1950's the Maine Geological Survey, along with other government agencies and mineral companies, continued to explore Maine's mineral potential. The search concentrated on nonmetallic materials such as sand and gravel, clay, limestone, and pegmatite minerals. Feldspar, along with minor amounts of beryl, niobium-tantalum ore, quartz, and mica, was produced from pegmatites in the southwestern part of

the state. Agricultural peat continued to be harvested, mostly from bogs in eastern Maine, and slate was mined and milled by the Portland-Monson Company.

The value of mineral production in Maine increased steadily following the war, with the exception of a slight drop in 1949, from about \$2.5 million in 1945 to \$13 million in 1955. By that time cement, which was produced exclusively by the Dragon Cement Company in Thomaston, accounted for over half of the value of Maine's mineral products.

There was little effort to search for metals in Maine between 1945 and 1955. Companies and federal agencies were more interested in investigating the metal potential of the Colorado Plateau and other western areas. However, exploration of the manganese ores in Aroostook County by the U. S. Bureau of Mines continued during the postwar years. The U.S. and Maine Geological Surveys, in a cooperative venture, conducted aeromagnetic investigations in the Katahdin Iron Works and Dead River areas in 1951 and 1952 respectively.

A resurgence of mineral exploration occurred in the mid 1950's, when the recent discovery of large base-metal sulfide deposits in the Bathurst, New Brunswick region stimulated new efforts to find similar deposits in Maine. Several companies started field work in the state. They were looking primarily for copper, nickel, lead, and zinc. These companies included American Smelting and Refining, New Jersey Zinc, Ventures Ltd., Texas Gulf Sulfur, American Metal Climax, Anaconda Company, and Kennecott Copper.

In 1957, Roland F. Beers, Inc. began a long and intensive study of the nickel deposits in Union and Warren, Maine. Beers received the first State mining lease of the modern era to develop the deposit, and conducted a winter drilling operation from the ice on Crawford Pond in early 1960. However, no actual mining was done at this time. The area investigated by Beers included the Harriman Prospect in Union (northeast of Crawford Pond), and he described the exploration program in this area in a 1962 publication (Beers and others, 1962).

A new agency, the Maine Mining Bureau, was created in 1955 to encourage and administer the development of mineral resources on State lands. The Maine Geological Survey supported the 1950's explorations through its ongoing program of research and publication. The Survey published the Mineral Resource Reference Map series and the Mineral Resource Index series to facilitate the location of mineral occurrences in Maine. In 1958 they released the first of a series of aeromagnetic maps covering various parts of the state. However, there was a cutback of mining company exploration in 1958, when a sharp drop in metal prices occurred.

THE 1960'S

Yearly mineral production in Maine during the late 1950's and early 1960's leveled off to between \$13 million and \$14 million. Production of several nonmetallic materials such as cement, peat, and feldspar either declined or remained at the

same level, while production of commodities such as clay, gemstones, and sand and gravel increased. Production of feldspar reached its lowest level since 1906. When the General Services Administration ended its strategic minerals stockpile program in 1962, mica and beryl mining ceased in Maine. Small amounts of granite were still quarried in Cumberland, Kennebec, Knox, Hancock, Waldo, and York Counties.

To stimulate continued exploration for metals, the Maine Geological Survey embarked on a 5-year program to evaluate metal prospects using current exploration technology adapted to Maine's complex geology. In 1960 a geological-geophysical-geochemical study of a zone of magnetic anomalies in Penobscot County was completed, the results of which were published in 1961 in the Survey's first bulletin in their Special Economic Studies Series. During the next three years, three other studies were completed and published, two of which covered areas of major base-metal potential in coastal Hancock and Washington Counties. The Survey also stepped up the bedrock mapping program. The U.S. Geological Survey continued aeromagnetic surveys and geochemical field studies, and the U.S. Bureau of Mines conducted economic investigations.

By the summer of 1961, there was a renewed flurry of exploration in Maine. As metal prices began to rise in the early 1960's, exploration by private concerns was stepped up. This increased activity was due in part to the working agreements reached by the large landowning paper companies and the mining companies to prospect and develop the mineral resources of paper company lands. Among the companies prospecting for metals at this time were Black Hawk Mining near Blue Hill, Penobscot Mining at Brooksville, and Anaconda Copper and Bear Creek near Parmachenee Lake.

It appeared that Maine's first metal mine in half a century would be opened in the 1960's near Blue Hill. In May, 1961, Charles D. Robbins acquired claims that had been staked on Second Pond. Robbins then transferred these claims to Black Hawk Mining Ltd., a Canadian public company (J. R. Rand, pers. comm.). A 1962 agreement between Black Hawk and Denison Mines Ltd. of Toronto resulted in extensive underground work and development of the ore body during 1964 and 1965. As a result of this work, the deposit was estimated to contain reserves of 4.5 million tons. However, work was suspended in 1966 due to unfavorable employment and economic conditions.

The Knox Mining Company (formerly Roland F. Beers, Inc.) continued to explore the nickel deposits of the Union area during the 1960's. In 1965 they discovered a significant nickel-copper deposit southwest of Crawford Pond in the town of Warren. Exploratory drilling between 1966 and 1974 outlined the ore body, but mining was not economically feasible.

In 1965 Callahan Mining Corporation of New York acquired the old Harborside Copper Mine in Brooksville. Originally opened in the 1880's, the Harborside Mine had been leased by Penobscot Mining Corporation in the mid 1950's. The latter company had staked claims on Goose Falls Pond and delineated a sulfide ore body. Callahan Mining obtained permis-

sion from the State to temporarily drain Goose Pond, which was a tidal inlet, in order to develop an open pit copper-zinc mine at the Harborside property. They built a flotation mill to extract copper and zinc concentrates from the ore, and began mining in 1968. The copper concentrates were shipped to the Noranda smelter in Gaspé, while the zinc concentrates went to a smelter in Pennsylvania.

Exploration for metallic ore deposits by both domestic and foreign companies increased during the mid and late 1960's. James R. Dunn and Associates explored a former copper prospect near Appleton. Dolsan Mines of Montreal drilled a mineralized area near Pembroke. In the northern mineral belt, Noranda Mines of Toronto, through its U. S. subsidiary East Range Company, explored the Catheart Mountain porphyry copper-molybdenum deposit south of Jackman. Another Toronto company - Spooner Mines and Oils - also was active in the Catheart Mountain area and other localities in northern Maine. Humble Oil and Refining of Houston prospected for molybdenum and copper under a cooperative agreement with Spooner.

In 1967 John S. Cummings, manager of the James W. Sewall Company's geology division, organized a joint venture comprised of Callahan Mining Corporation, New Jersey Zinc Company, Superior Oil Company, and U. S. Smelting, Refining & Mining Company. This group, called the "Northeast Joint Venture", was formed to search throughout New England and the Maritime Provinces, principally for base metals. The initial operating vehicle for this search was the J. W. Sewall Co., followed by J. S. Cummings, Inc. of Bangor during the period 1974-1982 (Cummings, 1988).

By 1969, the value of Maine's mineral production reached \$20.2 million. This increase reflected the greater production and value of cement and dimension stone, as well as the mining of copper and zinc at the Callahan Mine in Brooksville. Production of peat reached its lowest level since 1961, while production of feldspar, except for 1968, also declined. Scrap mica was mined in 1969 for the first time since 1962. Production of sand and gravel generally declined after 1965. Figures for clay and gemstones remained relatively constant during the last half of the decade.

During the sixties, state and federal agencies continued to support exploration of Maine's mineral resources through field studies, laboratory research, and publications. The Maine Geological Survey published a new bedrock geologic map of the state in 1967. In 1969 the Mine Reclamation Law was passed. This legislation required that mining companies submit a comprehensive site rehabilitation plan prior to the start of mining. Companies also were required to post bond with the State to ensure satisfactory reclamation.

THE 1970'S

The value of mineral production in Maine increased steadily from \$21.9 million in 1971 to \$43.2 million in 1977. This increase was due largely to increased production of copper, zinc,

cement, clay, and sand and gravel, and to inflation. In the early 1970's, a group of mineral collectors discovered a prolific series of tourmaline pockets at the Dunton mine in Newry, and the Plumbago Mining Corporation was formed to market gem tourmaline from this strike. The state legislature had designated tourmaline as the official State Mineral in 1971, and the find at Newry re-established Maine as a significant producer of rare pegmatite minerals. Exploration occurred at other pegmatite localities, and several small-scale gem prospects were opened during this decade.

No feldspar was produced between 1970 and 1975. Three granite quarries in York and Hancock Counties continued to produce dimension stone for architectural use. Underground production of slate at the Portland-Monson Slate mine in Monson was suspended from late 1973 to 1975 while a new shaft was sunk.

The 107th Legislature made changes in the Maine mining laws, effective in November, 1975. The elimination of lease terms confined by statutes was the most significant change. The Bureau of Geology was given the authority to negotiate lease terms for mining on the State's public lands, and to oversee prospecting and staking of mining claims on those lands. The makeup of the Maine Mining Bureau and the structure of licensing and rental fees were also changed.

In 1972, after 5 years of production, Callahan Mining closed its copper-zinc mining and milling operation at Harborside in Brooksville due to depletion of reserves. During this time the Callahan Mine had yielded 800,000 tons of ore grading 5.5% zinc, 1.25% copper, 0.5% lead, and 0.5 oz/ton silver (F. M. Beck, pers. comm.). Prior to closing of the mine, the Goose Pond Reclamation Society was formed to oversee the reclamation of the mine area. This group consisted of four residents of Brooksville, two state representatives, and one mining company representative. In a novel reclamation scheme the open pit, which was actually a part of Goose Cove that had been drained and dammed to allow mining, was flooded by tidewater and used for aquaculture of oysters and salmon. This business was called Maine Sea Farms. It continued until 1979 and was a pioneer for Maine aquaculture.

Late in 1972, Kerramerican, a subsidiary of Kerr Addison of Toronto, commenced production at the Black Hawk Mine in Blue Hill. The ore was processed on site for zinc and copper concentrates, which were shipped out of state for smelting. Mining continued until the fall of 1977. Based on extrapolation of 1976 statistics, it is estimated that the total output of the Black Hawk Mine during this period was approximately 1,000,000 tons containing 7.35% zinc, 0.89% copper, and 0.35% lead (F. M. Beck, pers. comm.). After operations ceased, equipment was removed from the Black Hawk Mine and the mine openings were sealed with concrete bulkheads. To reclaim the sulfide tailings, glacial till and topsoil were graded over the tailings and reseeded.

During the early and mid 1970's, American and Canadian concerns continued exploration, primarily for base metals. International Paper Company, along with its newly acquired sub-

sidary General Crude Oil and Minerals, and Kerramerican conducted exploratory drilling on International Paper land near Square Lake. Knox Mining Company continued investigations begun in the 1960's of the copper-nickel deposit in Warren, but the project was not economically viable at the time and was shelved by 1976.

The Northeast Joint Venture formed in 1967 continued its exploration activities through 1974, when Callahan Mining and New Jersey Zinc dropped out of the group. (U.S. Smelting, Refining & Mining had dropped out in 1970.) The remaining partner, Superior Oil, was then joined by Louisiana Land & Exploration Company. Exploration by the reconstituted Northeast Joint Venture continued under the management of J. S. Cummings, Inc. In 1973 Northeast Joint Venture discovered a massive sulfide deposit in Parmachenee, named the Ledge Ridge deposit, containing several million tons of zinc, lead, and copper mineralization. This was the first New England discovery of a buried sulfide deposit exceeding 1 million tons (Cummings, 1988).

Silver Stack Mining of Montreal conducted a drilling program at the Big Hill sulfide deposit in Pembroke during the 1970's, attempting to extend the known reserves of silver ore previously located by Dolsan Mines. Standard Metals Company explored for lead and zinc on Brown Company land in Maine, and Kerr-McGee evaluated the uranium potential along the Maine-New Hampshire border. Superior Mining evaluated the nickel potential of the Katahdin massive sulfide deposit, which had been held for many years by Allied Chemical as a potential sulfur reserve.

In September, 1977, Northeast Joint Venture discovered a 36 million-ton massive copper-zinc sulfide deposit at Bald Mountain in T12 R8, Aroostook County, Maine. It was estimated by some to be the third most significant copper discovery on the North American continent since the 1950's. Moreover, it was considered to be the only world-class discovery east of the Mississippi River during the period 1943-1983 (Cook, 1986).

The discovery of the Bald Mountain deposit was the culmination of years of exploration by Maine geologist John S. Cummings, of J.S. Cummings, Inc., in Bangor. Utilizing innovative geochemical techniques coupled with persistence, patience, and trial and error, Cummings pinpointed the deposit in an assemblage of volcanic rocks which extend for approximately 130 miles in a belt 50-60 miles wide across north-central Maine. He subsequently documented this and other sulfide discoveries, along with related prospecting methods, in a book titled "Geochemical Detection of Volcanogenic Massive Sulphides in Humid-Temperate Terrain" (Cummings, 1988).

Spurred on by the Bald Mountain discovery, exploration continued in the northern and coastal volcanic belts. Newmont Exploration, Noranda Mines, Phelps Dodge Exploration East, Getty Minerals Company, and Superior Mining opened offices in Bangor from which exploration activities throughout the state were directed. Getty Minerals began an exploration program in 1978 searching for base metals in northern Maine. This pro-

gram, managed initially by Larry Wing and then by F.M. Beck, Inc. of Yarmouth, led to the 1979 discovery of the Mount Chase massive sulfide deposit. The Mount Chase deposit is located about 10 miles north of Patten in T6 R6, Penobscot County.

Many other exploration activities also occurred in the 1970's. Northgate Exploration of Toronto looked for uranium and molybdenum in Hancock and Washington Counties. Chiasma Consultants of Portland evaluated the uranium potential in part of western Maine under a Federal NURE contract. Scintilore Exploration prospected for copper, zinc, and silver at the Big Hill property in Pembroke. Houston Oil and Minerals was active in the Chain of Lakes area. Aquitaine Company of Canada continued their geophysical and drilling program in Bowman and Oxbow Townships. Other exploration firms active in the state included Rio Tinto, Allied Chemical, Bethlehem Steel, and General Crude Oil.

MAINE MINERAL RESOURCES ASSOCIATION

In 1977 the Maine Mineral Resources Association (MMRA) was established. The founders felt that the minerals industry needed a forum for promoting the economic well-being of the State of Maine through the responsible development and production of Maine's mineral resources. The aims of the MMRA are: to encourage interaction among those interested in the exploration, extraction, processing and use of mineral resources; to communicate with the public on matters related to mineral resources; and to provide a forum for carrying out these aims.

Membership in the MMRA has fluctuated in direct response to the level of mineral exploration activity occurring in Maine. Over the years to the present day, the MMRA has provided valuable service to the public, educators, and government on matters concerning Maine's mineral resources. The MMRA desires close cooperation between these entities and the mineral industry in developing economically and environmentally sound policy and regulations for the state.

THE 1980's

Exploration continued into the 1980's in the volcanic belt of north-central Maine and along the coastal volcanic belt of Maine's southeastern coastal region. In 1981, prompted by a major jump in the price of silver, Scintilore Exploration drilled 20,000 feet of core at its prospects in the Pembroke area. Superior Mining Company and Louisiana Land & Exploration Company continued to gather environmental and metallurgical information on the Bald Mountain prospect. In 1982 the state of Maine passed a severance tax bill on the mining of metallic minerals.

Mineral output in Maine declined to an eleven-year low of \$26.4 million in 1983. Nevertheless, mineral investigations continued throughout the early 80's. Some of the active companies were Scintilore Exploration Ltd. and North American Exploration, along with reconnaissance programs by Ap-

alachian Resources, Inc., F. M. Beck, Inc., FMC Corporation, GCO Minerals Company, Newmont Exploration Ltd., Phillips Petroleum Company, and Santa Fe Mining, Inc.

Late in 1985, Chevron Resources Company acquired Getty's interest in the Mount Chase deposit; and most recently (1990), Horizon Gold Shares Inc. has reached an agreement in principal to purchase this property from Chevron. In 1989 Boliden Resources Inc. acquired the Bald Mountain deposit.

Industrial Garnet Extractives developed the Wing Hill Mine in Rangeley for garnet-bearing diorite. The garnet was separated at the Bell Minerals Company feldspar mill in West Paris, and was used for a variety of industrial products including water filters, abrasives, and packing media. This operation was one of four garnet producers in the United States. It closed in May, 1988 due to supply and milling problems.

In 1984, the Mineral Resource Division of Boise Cascade Corporation began a 5-year reconnaissance program to assess the mineral potential of its lands in Maine. The Penobscot Indian Nation's Mining and Minerals program completed the first year of a total mineral resource evaluation of Penobscot and Passamaquoddy Indian Trust Lands. The tribal Trust Lands comprise about 120,000 acres scattered across the central part of the state. Utah International continued its search for base and precious metals in the Jim Pond area in northern Franklin County.

State and federal agencies have carried out recent programs to aid mineral development in Maine. A cooperative effort of the Maine Geological Survey and U. S. Geological Survey has generated a five-volume atlas that evaluates peat resources throughout the state. This work was complemented by a study by the Maine Geological Survey and Maine Office of Energy Resources, funded by the U. S. Department of Energy, to evaluate the fuel potential of the state's peat resources.

The U.S. Bureau of Mines assisted in an evaluation of waste slate produced by the Portland-Monson Slate Company to determine potential byproduct use. The U.S. Geological Survey, with the assistance of the Maine Geological Survey, carried out bedrock mapping and other studies in western Maine for the Conterminous United States Mineral Appraisal Program (CUS-MAP). The Maine Geological Survey also oversaw prospecting activities on State lands, having been given that authority by the Legislature in 1977 in the newly revised law on mining and minerals.

During 1984 the Maine Geological Survey entered into a cooperative agreement with the U.S. Geological Survey to update and add information to the nationwide Mineral Resources Data System. Work began, and continues today, on recording information on location, exploration, development, and geology for each metallic deposit in the state. The Maine Geological Survey also began a 5-year project with the Minerals Management Service of the USGS to determine the stratigraphy and economic potential of seafloor sediments to a depth of 100 m off the Maine coast.

The 1985 Maine Legislature enacted Legislative Document 1466, "An Act to Clarify Certain Aspects of Mineral

Exploration, Development and Disclosure". Subchapter III of the law, "Mining on State Lands", covers exploration, claim staking, and mining on State-owned land. Subchapter IV of the law, "Information on Mining Exploration", specifies requirements for registration of persons or companies conducting mineral exploration in Maine, and for filing and publication of nature-of-intent to file for site location development permits. The Maine Geological Survey and Bureau of Public Lands are the two primary agencies responsible for overseeing exploration on State-owned lands.

Two noteworthy discoveries of gem materials and rare minerals were made in Oxford County in the late 1980's. In 1987, an excavation in the town of Sweden resulted in the chance discovery of a large vein of fine amethyst crystals. This deposit is being worked by Plumbago Mining Corporation. A group of mineral collectors (Sugar Hill Minerals) operating the Bennett Quarry in Buckfield found some exceptional pegmatite minerals in 1989. These included some of the largest and finest gem-quality crystals of pink beryl (morganite) ever found in the United States. Maine ranked fifth in the Nation in the value of natural semiprecious gemstones found.

CURRENT MINING AND EXPLORATION

Exploration for base and precious metals continues from the late 80's into 1990, albeit on a somewhat reduced scale from the early 1980's. Active companies or landowners include The Penobscot Nation, Champion Paper Company, a Boise Cascade - Teck joint venture named Oquossoc Minerals, and BHP-Utah. Three groups have announced plans to apply for mining permits from the Maine Department of Environmental Protection (DEP) and Land Use Regulation Commission (LURC). These are Boliden Resources, Inc. for the Bald Mountain deposit, Black Hawk Mining for the Warren nickel deposit (southwest of Crawford Pond), and BHP-Utah for their Alder Pond deposit. At this writing (September, 1990) the DEP and LURC are in the process of revising the regulations which would affect mining and should be ready to accept mining applications by 1991.

Production of nonmetallic minerals remains high and accounts for the total value of mineral production in Maine since the closing of the Kerramerican copper-zinc mine in Blue Hill in 1977. Maine currently produces enough sand, gravel, cement, peat, and some varieties of stone and clay to be self-sufficient. Sand and gravel is by far the most valuable and extensively produced of these commodities.

Slate continues to be produced at the Portland-Monson Slate mine in Monson; and New England Stone Industries, Inc. extracts granite from the Crotch Island quarry in Stonington. The Down East Peat Company in Deblois utilizes some of the most modern peat harvesting machinery in the world at Denbo Heath. This company has built a plant that burns peat or mixtures of peat and wood chips to generate electricity.

Several of the Oxford County pegmatites are being mined or prospected in response to the growing value of Maine tourmaline and other gem and mineral specimens. Plumbago Mining Corporation reopened the famous Mount Mica tourmaline mine in Paris in 1990, and occasional specimen mining is also occurring at quarries in Buckfield, Newry, Rumford, and other towns.

FUTURE POTENTIAL

The Bald Mountain copper discovery in Aroostook County, the need for alternative energy sources, and uncertainties concerning strategic mineral supplies from foreign countries are among the factors that have promoted recent mineral exploration activity in Maine and the northern Appalachians. Exploration is further affected by trends in metal prices. Periodic upturns in these prices give favorable status to mineral deposits previously considered to be of too low grade to mine profitably.

The crystalline rocks in Maine are potential hosts for the ores of critical and strategic metals, such as copper, zinc, lead, nickel, molybdenum, tin, tungsten, cobalt, beryllium, uranium, manganese, iron, gold, and silver. The Maine Geological Survey's basic mapping program generates information on distribution of rock types that is useful to private companies in their search for ore deposits containing these metals.

The potential for nonmetallic commodities in the state is reinforced by the large reserves of high-quality fuel grade and agricultural peat. A variety of natural building and construction materials still exist in large quantities in Maine. These materials include sand and gravel, crushed stone, granite, and slate. Mineral products with industrial and agricultural uses include limestone, garnet, diatomite, feldspar, mica, and clay.

The pegmatite rocks of western Maine continue to yield rare and exotic mineral species, including semiprecious gems. Tourmaline crystals mined at Newry in the 1970's supply high-quality gems to jewelers throughout the world. The thousands of hobbyists who come to Maine each year to collect minerals also make a significant contribution to the state's economy. As prospecting continues it is very likely that Maine pegmatites will yield additional rare minerals.

In conclusion, the geologic climate is favorable for commercial mineral discoveries in Maine. An equally favorable political climate for mineral production, and its resulting economic benefits, hopefully will be encouraged by the mining regulations currently being developed by the State of Maine.

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